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US ARMY MEDICAL RESEARCH LABORATORY

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REPORT NO. 473

TTS FOLLOWING PROLONGED EXPOSURE TO ACOUSTIC
REFLEX ELICITING STIMULI

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Studies on the Acoustic Reflex
Task 02
Psychophysiological Studies
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ABSTRACT

TTS FOLLOWING PROLONGED EXPOSURE TO ACOUSTIC REFLEX ELICITING STIMULI

OBJECT

To determine whether or not acoustic reflex activity can be maintained for relatively long periods of time.

RESULTS

Results indicate that with the present methodology, reflex contraction is not maintained, as evidenced by post exposure TTS.

CONCLUSIONS

Apparently differences in procedure from previous experiments resulted in failure to obtain prolonged AR contractions in this study. Simultaneous presentation of the AR eliciting stimulus and the fatiguing sound was one major difference.

RECOMMENDATIONS

Further research is necessary to determine whether AR contraction can be prolonged by proper programming and/or utilization of different eliciting stimuli. Obviously AR usefulness is restricted if activity cannot be maintained for longer than a few seconds.

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I. INTRODUCTION

Recently, considerable research attention has been devoted to acoustic reflex (AR) action (1, 2, 3, 4, 5, 7, 8). Reflex action has been shown to provide reasonably good protection against trauma from impulse noise for the human ear (1, 2). Upon cursory examination, it would appear that fatigability characteristics of the reflex would serve to limit its usefulness to protection from intermittent stimuli. However, several sources indicate that the AR action can be prolonged. Much of this evidence is summarized and presented in a monograph by Wersäll (8).

The conditions where AR activation was prolonged were those in which continued stimulation of the reflex involved successive short term presentations of stimuli varying considerably in frequency. Lüscher (6), for example, found that after AR fatigue had been induced by a 6889 cps tone, reflex contraction of unfatigued magnitude reappeared immediately following stimulation by a tone of 2734 cps, and after fatigue induced by a 5161 cps tone, a 'new' contraction followed 4096 cps stimulation. Others (4, 7) have also reported that the reflex can apparently be restored to full strength, or prolonged in contraction, by appropriate manipulation of the reflex activating stimuli.

Consideration of the above findings indicates that it might be possible to provide AR protection for continuous as well as intermittent sound by proper selection and programming of the AR activating stimuli. The present experiment is an investigation of this possibility.

II. METHOD, APPARATUS, AND SUBJECTS

A block diagram of the apparatus used in this investigation is given in Fig. 1, page 2.

The AR eliciting stimulus was presented in one ear (hereafter referred to as the AR ear) while simultaneously in the other ear (referred to as the test ear) the fatiguing sound was administered. The AR activating stimuli were tones of 700 and 3000 cps at 100 db sensation level (SL). The fatiguing stimulus was a white noise at 120 db SPL. Exposure time in all cases was 12.5 minutes.

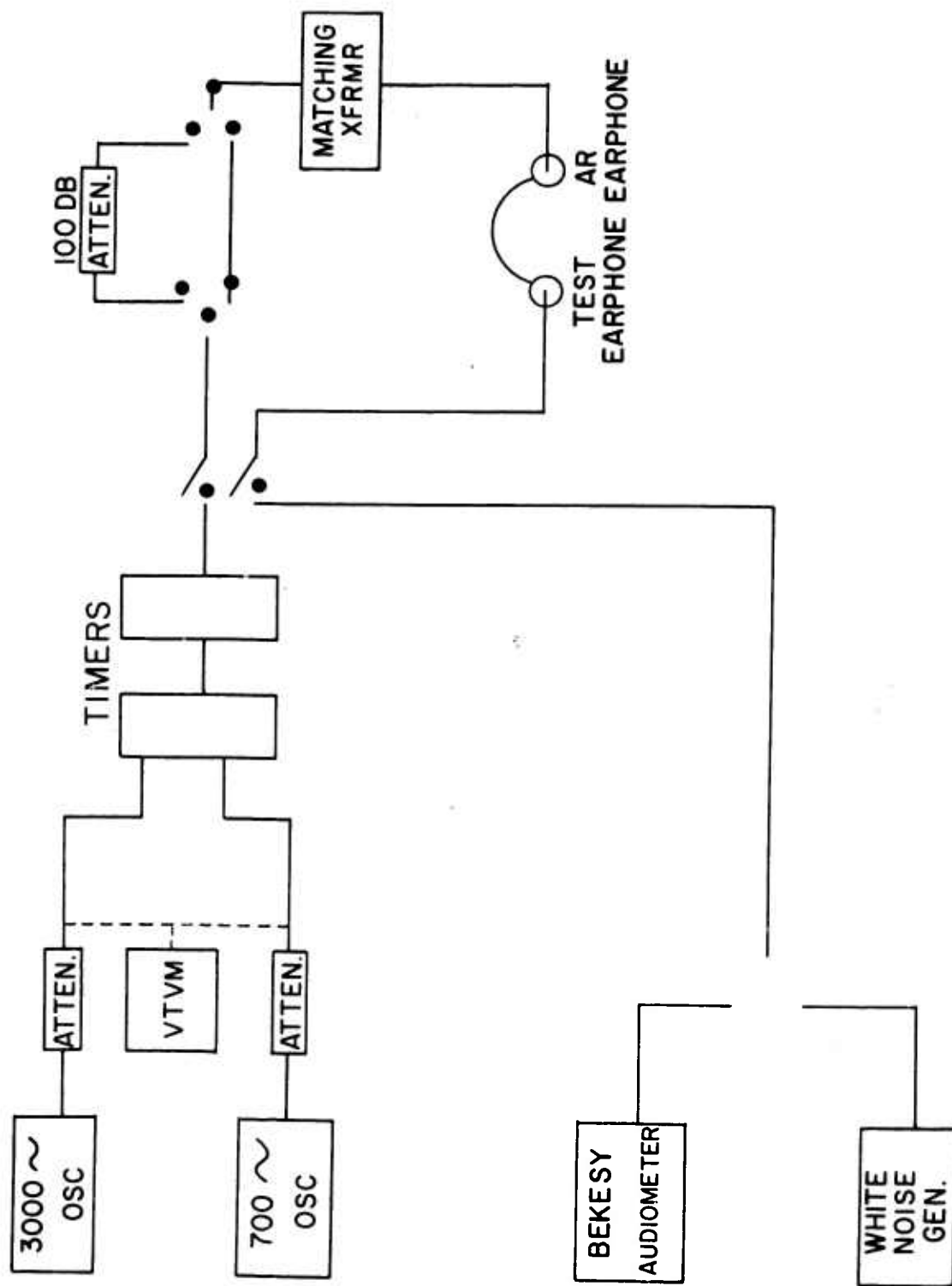


Fig. 1. Block diagram of the apparatus.

The investigation covered a total of six experimental conditions:

1. 700 and 3000 cps tones in the AR ear alternated every 5 sec.
2. 700 cps on continuously in the AR ear
3. 3000 cps on continuously in the AR ear
4. 700 cps alternated in the AR ear (on 5 sec., off .1 sec.)
5. 3000 cps alternated in the AR ear (on 5 sec., off .1 sec.)
6. No AR eliciting tone in the AR ear

In all six of the conditions, the 120 db SPL noise was administered to the test ear for the 12.5 minute duration of the experimental session. An experimental session consisted of a pre- and post-exposure 4000 cps audiogram of the test ear with one of the six experimental conditions listed above intervening between the pre- and post-exposure threshold determination. Each subject participated in all of the experimental conditions, thereby serving as his own control. Order of presentation of the experimental conditions was counterbalanced in order to minimize possible training effects.

Procedure was as follows: subjects were tested for possible hearing loss using the Grason-Stadler model E800 Bekésy Audiometer. Those with normal hearing (here defined as not more than 15 db hearing level at the octave frequencies 125 - 8000 cps) then were tested to determine the voltage across the earphones necessary to obtain 100 db SL for 700 and 3000 cps. Once these preliminary tasks were accomplished for each subject (S), experimental sessions were begun. An experimental session consisted of a pre-exposure 4000 cps audiogram of the test ear followed immediately by 12.5 min. exposure to the 120 db SPL noise in that ear. The appropriate experimental condition was simultaneously channeled into the AR ear. Immediately upon completion of exposure the post-exposure 4000 cps audiogram of the test ear was accomplished. Subjects were tested once per day.

Subjects used in this experiment were staff members of USAMRL ranging in age from 19-39 years. Upon completion of the six experimental sessions, each S was exposed to experimental condition 1 and pre- and post-exposure 4000 cps thresholds were determined in the AR ear in order to assess changes in acuity in that ear due to exposure to the eliciting stimuli.

III. RESULTS

Raw data for this experiment were the threshold shifts at 4000 cps obtained by comparing the pre- and post-exposure thresholds. We assume

that prolongation of the AR contraction by any of the experimental conditions utilizing various eliciting stimuli would result in smaller TTS (temporary threshold shift, a temporary decrease in auditory acuity) as compared with the control condition (number six) where no AR stimulus was provided. An analysis of variance revealed no significant differences among the five experimental conditions as compared to the sixth (control) condition. In other words, TTS was as great for the situations provided in conditions 1 through 5 where various "eliciting" stimuli were presented in hopes of prolonging reflex contraction as it was in condition 6 where no AR stimuli were presented.

Table 1 shows the mean TTS in the test ear for each of the 6 experimental conditions.

TABLE 1

Conditions	1	2	3	4	5	6
Mean TTS (in db)	16.1	16.2	13.4	16.4	14.7	17.9

Testing in the AR ear immediately after exposure to condition 1 resulted in a mean TTS in that ear of 22.7 db, somewhat greater than that occasioned by exposure to the "fatiguing" sound. In this case, then, the stimuli presented to protect the subject from fatigue actually produced more TTS than did the 120 db SPL noise from which he was to be protected. Obviously then, reflex action in this particular instance was not prolonged, or the ear sustained a loss in spite of reflex action.

IV. DISCUSSION

Efforts to prolong AR contractions in this experiment were apparently unsuccessful in spite of evidence in the literature suggesting that it was feasible. This does not mean, of course, that AR activation cannot be maintained, merely that in this specific instance it was not. The experimental procedures of the present study show at least one clear difference from those where reflex activation was maintained. Presentation of the fatiguing sound in the test ear was simultaneous with presentation of the eliciting tone in the reflex ear. Perhaps in the absence of the fatiguing sound reflex contraction would have continued, but a limitation of this nature would severely restrict practical application of this phenomenon. It is also possible that some other type of stimulus or eliciting signal could have maintained reflex contraction.

At least three workers in AR research have separately indicated reflex contractions are not well maintained when pure tones are used as stimuli.¹ Whether or not any stimulus can maintain contraction in the ipsilateral ear when the contralateral ear is simultaneously exposed to a high level noise is problematical and, indeed, unanswerable on the basis of evidence now available.

Future development of AR protective devices should be guided by consideration of the TTS likely to be produced by the eliciting stimulus. This would be a limiting factor in protecting against continuous noise by use of the AR technique, assuming other difficulties could be overcome.

Apparently further research is indicated to determine optimum types and amplitudes of sound for AR elicitation as well as proper methods, if any, of programming stimulation in order to maintain contraction. Also, perhaps more information on stimulation necessary to fatigue reflex activity as well as data on recovery time would be extremely useful.

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